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(51) INT CL<sup>4</sup>

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None

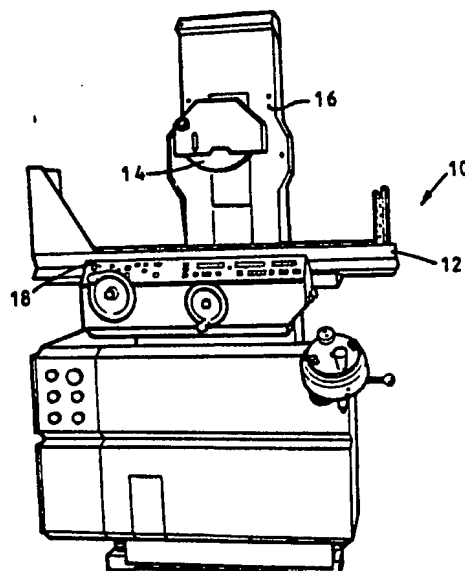
(58) Field of search

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## (54) Grinding machine control system

(57) A system for controlling the vertical movement of a grinding wheel of a surface grinding machine stores a vertical datum position set at a pre-selectable distance above a workplace. The system automatically selects a desired stop position for the wheel which is a pre-set distance (typically .2 inch) above the datum position. The grinding wheel is then lowered rapidly towards the datum position and a stop signal generated at the desired stop position. Because of inertia of the wheel, the latter continues moving until it reaches its actual stop position. Overshoot of the desired stop position is monitored by the control system which then makes a compensatory adjustment of the desired stop position. Typically, the inertial movement is added to the datum position with a further clearance safety factor of typically .003 inch. In subsequent grinding operations the wheel is lowered rapidly to the new desired stop position and is subsequently lowered at a slower grinding feed rate. The control system monitors the inertial movement of the wheel at each grinding operation and re-adjusts the desired stop position accordingly.

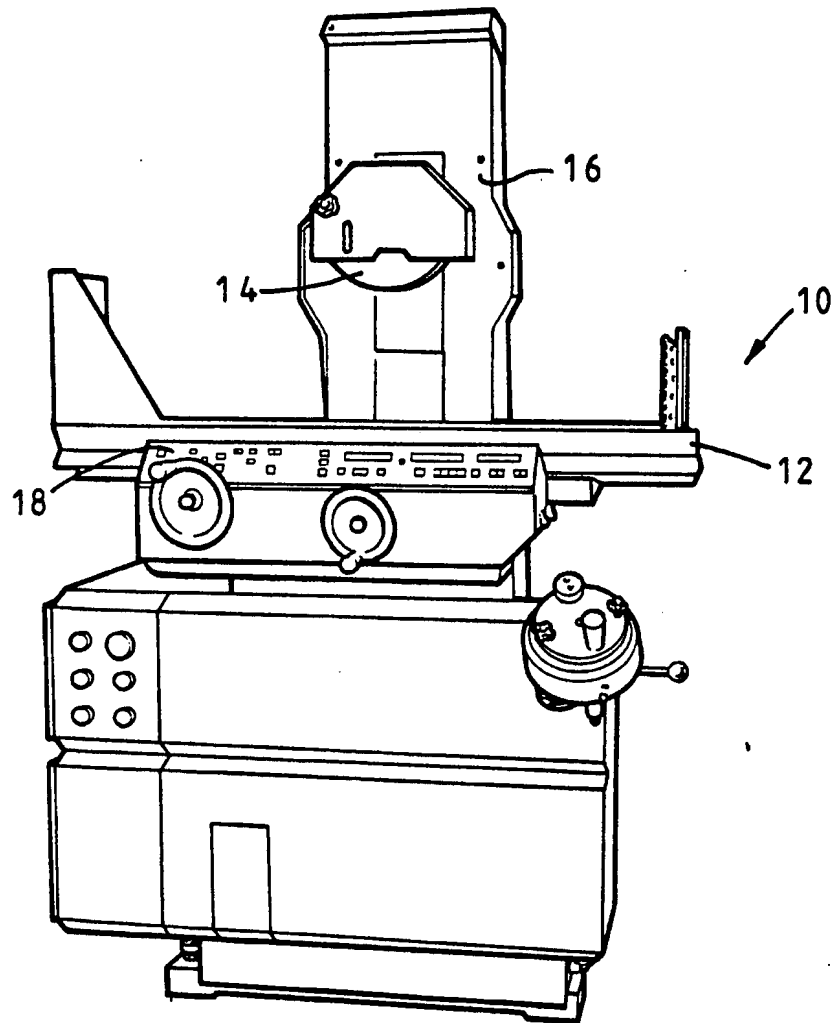


At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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Title: Improvements relating to grinding machines.

The present invention relates to grinding machines and in particular to control systems for grinding machines such as surface grinding machines.

A surface grinding machine has a traversable worktable which is normally hydraulically powered, and a grinding wheel which is supported on a feed system for moving the grinding wheel in a vertical direction towards and away from a workpiece on the worktable. When the upper surface of a particular workpiece is to be ground, the workpiece is secured in position and the grinding wheel is rapidly lowered to a pre-selected position to begin grinding. As the worktable is traversed, the grinding wheel is then lowered at a further, slower rate to contact the upper surface of the workpiece and effect grinding.

One of the problems associated with such grinding machines arises from the considerable inertia of the grinding wheel and its mounting structure. Because of this high inertia, it is not easy to stop the grinding wheel dead at a pre-selected datum position, and in fact the grinding wheel may continue to drop for several thousandths of an inch after a STOP signal has been applied to the grinding wheel drive motor. As a result of this, the grinding

wheel will actually stop below the selected datum position.

In order to keep the operational time of the grinding process to a minimum, it is desirable that grinding commences as soon as possible after the grinding wheel has reached its datum position. However, if the datum position is set at, say, .003 inch above the surface of the workpiece, because of the "overrun" of the grinding wheel past the datum position which may occur there is a real danger of the grinding wheel crashing into the workpiece surface, damaging the workpiece and possibly the grinding wheel and its drive mechanism. On the other hand, if the datum position is set sufficiently far above the workpiece surface to ensure that the wheel does not crash into the workpiece then the time lapse between the moment at which the grinding wheel stops near the datum position and the moment at which actual grinding commences will be relatively long compared with the situation where the grinding wheel is actually stopped very close to the workpiece.

Accordingly, the present invention provides a method of controlling movement of a grinding wheel of a surface grinding machine, the method comprising the steps of:

- a) selecting a vertical datum position of said grinding

- wheel and storing a signal representing said pre-selected datum position;
- b) selecting a desired stop position a pre-selected distance above said datum position and storing a signal representing said desired stop position;
  - c) lowering the grinding wheel towards said datum position at a first, rapid feed rate;
  - d) generating a stop signal at said desired stop position of said grinding wheel to stop said grinding wheel;
  - e) monitoring movement of the grinding wheel beyond said desired stop position to its actual stop position;
  - f) storing a signal representing the difference between said desired stop position and said actual stop position; and
  - g) adjusting said stored desired stop position relative to said stored datum position in dependence on said difference and storing a signal representing said adjusted desired stop position.

The present invention also provides a control system for controlling a drive of a grinding wheel of a surface grinding machine, the control system comprising:

- a) means for monitoring the vertical position of the grinding wheel;
- b) means for storing a signal representing a pre-selectable datum position of said grinding wheel;
- c) means for storing a signal representing a desired stop position a pre-selectable distance above said datum position;
- d) means for controlling said drive to lower the grinding wheel towards said datum position at a first, rapid feed rate;
- e) means for generating a stop signal when said grinding wheel is at said desired stop position to stop said drive;
- f) means for monitoring movement of the grinding wheel beyond said desired stop position to a second actual stop position of said grinding

wheel and storing a signal representing the difference between said desired stop position and said actual stop position; and

- g) means for adjusting said stored desired stop position relative to said stored datum position in dependence on said difference.

The present invention is further described hereinafter, by way of example, with reference to the accompanying drawing which illustrates one form of grinding machine having a control system according to the present invention.

The grinding machine 10 shown in the drawings has a worktable 12 for supporting a workpiece to be ground. A grinding wheel 14 is supported vertically above the worktable 12 on a vertical pillar 16, the grinding wheel mounting allowing vertical movement of the grinding wheel towards and away from a workpiece on the worktable 12.

A drive mechanism for the grinding wheel 14 enables the wheel to be vertically moved at two different rates, a first being a rapid feed rate to enable the grinding wheel to be moved quickly to a datum position prior to grinding, and a second, slower rate at which the grinding wheel is moved during grinding of a work piece. The drive mechanism for the grinding wheel 14 is controlled by a

control system 18.

To begin a grinding operation of a workpiece, an operator first lowers the grinding wheel to touch the upper surface of the workpiece. The position of the grinding wheel, which is continuously monitored by a position sensor (conveniently providing a digital read out), is then stored by the control system. The control system then automatically selects a datum position which can be preset by the operator to be well clear of (say, .003 inch above) the workpiece surface. This offset serves purely as a safety factor to take account of variations in the vertical dimensions of successive workpieces of the same type. The operator also enters into the control system the depth of material to be removed from the workpiece.

The drive to the grinding wheel is then activated and the grinding wheel is raised by the drive motor. The grinding wheel is then rapidly lowered by the drive mechanism until a STOP signal is generated by the control system. The system is pre-set to generate the STOP signal at a vertical position of the grinding wheel which is a pre-selected distance above the datum position. This pre-selected distance is typically .200 inch above the datum position.

When the STOP signal is generated, drive to the grinding

wheel ceases but because of the inertia of the grinding wheel the latter continues beyond the STOP position for a distance less than the pre-selected distance (typically .040 inch).

Both the position of the grinding wheel when the STOP signal is generated and the final, stationary position of the wheel are monitored to provide an "inertia" distance which is the difference between the two positions. This "inertia" distance is stored by the control system and added to the datum position to set a new STOP position. The control system then controls the drive motor to re-lower the grinding wheel rapidly to the workpiece using the "new" monitored pre-stop inertial figure to determine the point at which the STOP signal is generated.

For safety reasons a small margin is added to the new inertial figure of say .003 inches.

The worktable 12 then begins traversing as the grinding wheel is lowered at its second, grinding rate. Grinding of the workpiece therefore commences with the minimum of delay.

When the next workpiece is mounted on the work table for grinding, it is only necessary for the operator to lower the grinding wheel, the previous inertial figure being used

to stop the wheel at the safety margin (.003) above the workpiece prior to commencement of traverse.

Any variation of the actual STOP position of the wheel from this position is monitored by the control system which modifies the inertial figure for the next operation.

As the machine operation varies with friction/lubrication/age etc. the monitoring and modifying of the inertial stop figure maintains an accurate stop with safety margins in-built on a simple drive system.

CLAIMS:

- 1) A method of controlling movement of a grinding wheel of a surface grinding machine, the method comprising the steps of:
  - a) selecting a vertical datum position of said grinding wheel and storing a signal representing said pre-selected datum position;
  - b) selecting a desired stop position a pre-selected distance above said datum position and storing a signal representing said desired stop position;
  - c) lowering the grinding wheel towards said datum position at a first, rapid feed rate;
  - d) generating a stop signal at said desired stop position of said grinding wheel to stop said grinding wheel;
  - e) monitoring movement of the grinding wheel beyond said desired stop position to its actual stop position;
  - f) storing a signal representing the difference

between said desired stop position and said actual stop position; and

- g) adjusting said stored desired stop position relative to said stored datum position in dependence on said difference.
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- 2) A method as claimed in claim 1 further comprising lowering said grinding wheel towards said datum position at said first, rapid feed rate; generating a stop signal at said adjusted desired stop position of said grinding wheel and subsequently lowering said grinding wheel at a second, lower grinding feed rate whilst repeating steps e) to g) of claim 1.
  - 3) A method as claimed in claim 1 or 2 wherein said pre-selected datum position is .003 inch above a surface of a workpiece to be ground.
  - 4) A method as claimed in claim 1, 2 or 3 wherein said pre-selected distance of said desired stop position above said datum position is .200 inch.
  - 5) A method as claimed in claim 1 and substantially.

as hereinbefore described.

- 6) A control system for controlling a drive of a grinding wheel of a surface grinding machine, the control system comprising:
- a) means for monitoring the vertical position of the grinding wheel;
  - b) means for storing a signal representing a pre-selectable datum position of said grinding wheel;
  - c) means for storing a signal representing a desired stop position a pre-selectable distance above said datum position;
  - d) means for controlling said drive to lower the grinding wheel towards said datum position at a first, rapid feed rate;
  - e) means for generating a stop signal when said grinding wheel is at said desired stop position to stop said drive;
  - f) means for monitoring movement of the grinding wheel beyond said desired stop

position to a second actual stop position of said grinding wheel and storing a signal representing the difference between said desired stop position and said actual stop position; and

g) means for adjusting said stored desired stop position relative to said stored datum position in dependence on said difference.

7) A control system as claimed in claim 6 wherein said controlling means is operable to lower said grinding wheel towards said datum position at said first, rapid feed rate and subsequently lowering said grinding wheel at a second, lower grinding feed rate after generation of a stop signal at said adjusted desired stop position of said grinding wheel.

8) A control system for controlling a drive motor of a grinding wheel of a surface grinding machine substantially as hereinbefore described with reference to the accompanying drawings.